# Characteristics of maxillofacial morphology of Angle Class II patients with temporomandibular disorders involving crepitus

## Abstract

**Purpose:** To clarify the characteristics of maxillofacial morphology of Angle Class II orthodontic patients with temporomandibular disorders (TMD) involving crepitus suggesting osseous changes in the condyle, compared to Class II patients without TMD.

**Materials and methods:** Twenty-four Japanese females accompanied by Angle Class II malocclusion with crepitus and 24 females accompanied by Class II malocclusion without TMD were examined. Pretreatment panoramic radiographs were used to measure condylar ratio (condylar height / ramus height). Pretreatment lateral cephalograms were used to analyze skeletal and dental morphology. Angular and linear measurements were compared between groups. Multiple linear regression analysis was used to identify associations of overjet with other cephalometric measurement values in both groups.

**Results:** Class II patients with crepitus showed significantly smaller condylar ratio as compared to Class II patients without TMD. Class II patients with crepitus exhibited significantly greater clockwise rotation of the mandible, shorter ramus height, more retruded mandible, less labially inclined upper incisors, and smaller overjet. Overjet of Class II patients with crepitus was significantly associated with inclination of upper incisors and ramus height, whereas that of patients without TMD was significantly associated with inclination of both upper and lower incisors and sagittal intermaxillary relationship.

**Conclusion:** Significant smaller condylar ratio of Class II patients with crepitus suggested osseous changes in the condyle. Significant differences existed between morphological maxillofacial characteristics of Class II patients with and without crepitus. Overjet in Class II patients with crepitus correlated significantly with ramus height, attributed to resorbed deterioration and dysfunctional remodeling of the condyle.

## Introduction

Many studies [1-10] have described characteristics of the dentofacial morphology in orthodontic patients with temporomandibular disorders (TMD) such as internal derangement (ID). A small number of studies [4-6,11,12] have also described those in patients with osteoarthritis/osteoarthrosis (OA) of the temporomandibular joint (TMJ). All studies have shown the characteristics to be backward rotation and retruded position of the mandible. Angle Class II malocclusion is most related to backward rotation and retruded position of the mandible attributed to bilateral ID and/or OA of the TMJ [1,3]. However, all studies describing the characteristics of the dentofacial morphology of ID and/or OA have included Angle Class I and Class III patients among the subject cohort. Osseous changes of the condyle could be linked to TMJ OA and ID because several authors have supported the contention that OA is associated with the progressive development of ID [13-15]. Therefore, understanding of dentofacial morphology of Angle Class II patients those originate in bilateral osseous changes of the condyle may outline orthodontic treatment plan for the patients.

To diagnose and treat patients with skeletal malocclusion, the assessment of osseous changes of the condyle is important because patients may develop osseous change of the condyle during orthodontic treatments, including surgical orthodontic treatment [1,2,16]. In Diagnostic Criteria for TMD (DC/TMD) [17], crepitus detected with palpation is necessary for diagnosis of degenerative joint disease with osseous changes of the condyle. Therefore, the finding of crepitus at the initial examination could suggest osseous changes of the condyle.

The objective of the present retrospective study was therefore to clarify characteristics of the maxillofacial morphology in Angle Class II orthodontic patients with TMD involving crepitus suggesting osseous changes in the condyle, compared to Angle Class II orthodontic patients without TMD.

## Materials and methods

### *Subjects*

Twenty-four Japanese females accompanied by Angle Class II malocclusion with TMD involving bilateral crepitus (Crpt group) were examined. Another 24 Japanese females accompanied by Angle Class II malocclusion without crepitus (non-Crpt group) were also examined as controls. Criteria for including a Angle Class II patient in the study were: 1) overjet >4.5 mm; 2) ANB angle >5.0°; 3) full Class II or end-to-end molar relationships; 4) age ≥15 years at initial examination; and 5) intention to be treated at the Orthodontic Clinic of Fukuoka Dental College Medical and Dental Hospital (see Table 1,2).

Criteria for excluding a subject from the study were: 1) congenital anomalies; 2) history of rheumatoid arthrosis; 3) history of trauma; and 4) previous orthodontic treatment.

Mean ages at initial examination for the Crpt and non-Crpt groups were 26.2 ± 10.2 years and 22.4 ± 8.1 years, respectively. The number of Angle Class II patients who underwent orthognathic surgery was 12 in each of the Crpt and non-Crpt groups. As shown in Table 1, all patients in the Crpt group displayed crepitus during examination, and almost patients in the Crpt group displayed history of noise (click or crepitus) reported by patients. No patients in the non-Crpt group had symptoms according to the DC/TMD [17].

To measure condylar height and ramus height [15,18], panoramic radiographs taken at initial examination were used. Radiographs were obtained using an AZ 3000 system (Asahi Roentgen, Kyoto, Japan), Cypher E system (Asahi Roentgen, Kyoto, Japan), or Veraviewepocs 2DE system (Morita, Tokyo, Japan). The head of the patient was exposed in an optimum position according to the operating instructions. Standardized lateral cephalograms obtained at pretreatment (initial examination) from all subjects were used to analyze skeletal and dental morphology. The Ethics Committee of Fukuoka Dental College approved the protocols of this retrospective study.

### *Measurement of condylar ratio and cephalometric analysis*

Condylar ratio derived from Kjellberg [18] was measured. Fig. 1 shows landmarks and measurements used in this study. Fig. 2 shows the lateral cephalometric measurements employed in this study. The McNamara line was perpendicular to the FH line through the nasion. Measurement points of #1-4 linear measurements were projected parallel to the McNamara line. Linear and conventional angular measurement values were compared between the Crpt and non-Crpt groups.

### *Statistical methods*

To assess the reproducibility of this method, 10 subjects were randomly selected. All angular and linear measurements were repeated at least 4 weeks after the first measurements. The combined error ($S_e$) and coefficient of reliability were calculated according to Houston [19]. $S_e$ was estimated using the formula $S_e^2=\sum d^2/2n$, where d is the difference between the first and second measurements, and n is the sample size. The coefficient of reliability was estimated by the formula $1-S_e^2/S_t^2$, where $S_t$ is the total variance of the measurement. For all measurements, the coefficient of reliability was above 95% and was considered to be within acceptable limits (Table 3).

Student's or Welch's *t* test or the Mann-Whitney *U* test was used to compare condylar ratio [15] or cephalometric angular or linear measurement values between the Crpt and non-Crpt groups. Multiple linear regression analysis was used to identify associations between overjet (distance between the labial surface of the lower incisors and the labial aspect of the incisal edge of the upper incisors) and other cephalometric angular or linear measurement values in both groups. Overjet and other measurement values were used as dependent and independent variables, respectively. Stepwise variable selection was used to identify good association of dependent variables to independent variables. Statistical analyses were performed using the SPSS® version 20.0 statistical package (SPSS, Chicago, IL). The level of statistical significance was set at a probability level of 0.05.

## Results

Table 4 shows the results of measurements of condylar ratios. Condylar ratios were significantly smaller in the Crpt group than in the non-Crpt group ($P < 0.01$). Tables 5 and 6 show the results of angular and liner cephalometric measurements. Tables 5 and 6 also show the $P$ values for statistical tests. For comparison of the mandibular morphology between Crpt and non-Crpt groups, mean values of SN-mandibular plane angle, Frankfort-mandibular plane angle, GZN, NSM, and Y-axis were significantly larger in the Crpt group than in the non-Crpt group ($P < 0.01$ and $P < 0.001$). Mean Ramus angle was significantly smaller in the Crpt group than in the non-Crpt group ($P < 0.001$) (Table 5). Mean values for Cd-Go and Cd-Gn in the Crpt group were significantly smaller than those in the non-Crpt group ($P < 0.01$ and $P < 0.001$) (Table 6).

Mean values for SNB, SNP, facial angle (Table 5), and Pog to McNamara line (Table 6), which represent the anterior-posterior position of the mandible, were significantly smaller in the Crpt group than in the non-Crpt group ($P < 0.01$ and $P < 0.001$). Mean values for SNA angle (Table 5) and Pt A to McNamara line (Table 6), which represent the anterior-posterior position of the maxilla, were also significantly smaller in the Crpt group than in the non-Crpt group ($P < 0.05$ and $P < 0.01$). Therefore, there were no significant differences in mean values for ANB angle (Table 5) and Wits appraisal (Table 6), which represent sagittal intermaxillary relationships, between the Crpt and non-Crpt groups.

Mean values for U1 to SN and U1 to FH, which represent labial inclination of the upper incisors, were significantly smaller in the Crpt group than in the non-Crpt group ($P < 0.05$ and $P < 0.01$) (Table 5). Mean Overjet, representing the distance between the labial surface of the lower incisors and the labial aspect of the incisal edge of the upper incisors, was also significantly smaller in the Crpt group than in the non-Crpt group ($P < 0.05$). Mean ANS-U1, representing the vertical distance between the anterior nasal spine and the incisal edge of the upper incisors, was significantly larger in the Crpt group than in the non-Crpt group ($P < 0.05$) (Table 6).

Tables 7 and 8 show the results of multiple linear regression analysis of influence on Overjet. Overjet is considered to be influenced by both sagittal intermaxillary and interincisal relationships. Overjet in the Crpt group was significantly associated with U1 to FH and Cd-Go (Table 7), whereas Overjet in the non-Crpt group was significantly associated with Wits appraisal, U1 to FH, and L1 to Mandibular pl. (Table 8). Regression models of the Crpt and non-Crpt groups offered prediction capabilities of about 55% ($R^2 = 0.554$, $P < 0.001$) and about 63% ($R^2 = 0.627$, $P < 0.001$), respectively.

**Discussion**

All previous studies [4-10] describing characteristics of the dentofacial morphology of TMJ ID or OA patients have included Angle Class I and Class III patients among the subject cohorts. To clarify characteristics of the maxillofacial morphology specific to Angle Class II orthodontic patients with TMD involving osseous changes of the condyle, the present study excluded Class I and III patients. Class II patients with crepitus showed significantly more clockwise rotation of the mandible and a shorter ramus height as compared to Class II patients without TMD symptoms (Tables 5, 6). Class II patients with crepitus also showed a significantly more retruded mandible as compared to Class II patients without TMD symptoms (Tables 5, 6). These mandibular morphological chracteristics of patients with crepitus were similar to those with TMJ OA or ID reported previously [4-10], but this study shows the characteristics more precisely by excluding Class I and III patients from among the subjects investigated.

Angle Class II patients with crepitus also had a significantly a more retruded maxilla as compared to Class II patients without TMD symptoms (Tables 5, 6). This meant that there were no significant differences in sagittal intermaxillary relationship between Class II patients with and without crepitus (Tables 5, 6). Angle Class II patients with crepitus showed significantly less labially inclined upper incisors as compared to Class II patients without TMD symptoms (Table 5), although Class II patients both with and without crepitus had labially inclined upper incisors. Class II patients with crepitus also exhibited significantly smaller overjet as compared to Class II patients without TMD symptoms (Table 6). This study showed novel maxillofacial characteristics of Class II patients with osseous changes of the condyle by excluding Class I and III patients.

With regard to the overjet, which represents the distance between the labial surface of the lower incisors and the labial aspect of the incisal edge of the upper incisors, we considered overjet as a phenotype comprising both skeletal and dental morphologies, because both sagittal intermaxillary and interincisal relationships influence overjet. Multiple linear regression analysis was therefore performed to identify associations of overjet to other cephalometric angular or linear measurement values.

An amount of overjet in Angle Class II patients with crepitus was significantly associated with more labially inclined upper incisors and shorter mandibular ramus height (Table 7). More labially inclined upper incisors were also significantly associated with an amount of overjet in Class II patients without TMD symptoms, whereas shorter mandibular ramus height was not significantly associated with an amount of overjet among Class II patients without TMD symptoms (Table 8). From these results, maxillofacial characteristics of Class II patients with crepitus may originate in shorter mandibular ramus height. An explanation of this origin could be considered as follows.

Arnett et al. [20] suggested that unstable occlusion produces compressive deflection of the condyle during interdigitation of the teeth with masticatory muscular force, and compressive resorption of the condyle and subsequent mandibular retrusion may result. Muscles attached to the mandibular ramus may then retract the ramus upward and forward [21]. The digastric and mylohyoid muscles of patients with short mandibular ramus height may retract the mandibular body backward and downward. After growing up, Class II patients with osseous changes of the condyle may show shorter ramus height attributable to resorbed deterioration and dysfunctional remodeling of the TMJ condyle [1,3,22], and subsequent clockwise rotation of the mandible.

In the present study, Angle Class II patients with crepitus showed significantly smaller condylar ratios as compared to Class II patients without TMD symptoms (Table 4). The result suggested that osseous change of the condyle occurred in all subjects with crepitus. No doubt CT or MRI is better for detecting osseous changes of the condyle and is necessary for diagnosis of TMJ OA [17,23], Ahmad et al. [23] indicated in a part of a multi-site RDC/TMD that about 99% of CT-diagnosed non-OA is detected using panoramic radiography, so that the finding of condylar ratio by panoramic radiography at the initial examination could be helpful to judge whether additional examination with CT or MRI is necessary.

From a clinical perspective, the present results suggest that orthodontists should pay attention to the potential for osseous changes of the condyle when growing Class II patients show a more retruded maxilla and less labially inclined upper incisors, in addition to a clockwise-rotated mandible. When we diagnose growing Class II patients with such maxillofacial morphology, we should examine the TMJ in detail and explain the potential for future degenerative changes of the condyle to the patients.

The present results also suggest that Class II patients with osseous changes of the condyle might not have as much clockwise rotation of the mandible before osseous changes appear, so mandibular counter-clockwise rotation could help in achieving remission of osseous changes of the condyle in Class II patients. For the last two decades, many articles [24-26] have reported mandibular counter-clockwise rotation accompanied by upper and lower molar intrusion using temporary anchorage devices in skeletal openbite cases. Therefore, for non-surgical orthodontic treatment of Class II patients with osseous changes of the condyle, mandibular counter-clockwise rotation accompanied by upper and lower molar intrusion using temporary anchorage devices may be recommendable [27].

## Conclusions

- Angle Class II patients with crepitus showed significantly smaller condylar ratios as compared to Class II patients without TMD symptoms. The result suggested that osseous change of the condyle occurred in all subjects with crepitus.
- Angle Class II patients with crepitus showed significantly more clockwise rotation of the mandible, shorter ramus height, greater retrusion of the mandible, and less labially inclined upper incisors as compared to Class II patients without TMD symptoms. Class II patients with crepitus also showed a significantly smaller overjet.
- Overjet of Class II patients with crepitus was significantly associated with upper incisor inclination and mandibular ramus height. Resorbed deterioration and dysfunctional remodeling of the TMJ may contribute to shorter condylar and ramus height in Class II patients with osseous changes of the condyle. The severity of resorbed deterioration and dysfunctional remodeling thus seem to directly influence overjet in Class II patients with osseous changes of the condyle.

**Ethical approval**

The Ethics Committee of the dental collage approved the protocols of this retrospective study (no. 267).

**Conflict of interest**

The authors have no conflict of interest to disclose.

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**FIGURE LEGEND**

Fig. 1. - Landmarks and measurements used in this study. 1, most upper point of condylar head; 2, a point intersecting perpendicular projection of point 1 and ramus tangent; 3, deepest point between coronoid process and condylar process; 4, perpendicular projection of point 3 on ramus tangent; 5, intersection between ramus tangent and inferior mandibular line. 6, condylar height (a distance between point 2 and 4); 7, ramus height (a distance between point 4 and 5).

Fig. 2. - Cephalometric measurements. a: angular measurements. 1, ANB; 2, SNA; 3, SNB; 4, SNP; 5, Facial angle; 6, Mandibular pl. to SN; 7, Mandibular pl. to FH; 8, Gonial angle; 9, GZN; 10, Ramus angle; 11, NSM; 12, Y-axis; 13, U1 to SN; 14, U1 to FH; 15, L1 to Mandibular pl. b: linear measurements. 1, N-Me; 2, ANS-Me; 3, ANS-U1; 4, L1-Me; 5, N-Ba; 6, McNamara line to Pt A; 7, McNamara line to Pog; 8, Cd-Gn; 9, Cd-Go; 10, Go-Pog´; 11, Wits appraisal; 12, Overjet; 13, Overbite. McNamara line was perpendicular to the FH line through the nasion. Measurement points of #1-4 linear measurements were projected parallel on the McNamara line. Each distance between two projected points was measured.

Table 1. Symptom of TMJ, overjet, and overbite in Crpt group. All patients in the Crpt group displayed crepitus during examination. Noise means click or crepitus reported by patients. Y: Yes, N: No.

| Crpt | history | | | examination | | | overjet | overbite |
|---|---|---|---|---|---|---|---|---|
| group | noise | lock | pain | crepitus | lock | pain | (mm) | (mm) |
| #1 | Y | N | Y | Y | N | N | 10.1 | 2.0 |
| #2 | N | Y | N | Y | N | N | 11.3 | 0.0 |
| #3 | Y | Y | Y | Y | N | Y | 4.6 | -3.4 |
| #4 | Y | N | Y | Y | N | N | 10.2 | -4.0 |
| #5 | Y | Y | Y | Y | Y | N | 8.8 | -0.1 |
| #6 | Y | Y | N | Y | N | N | 4.7 | -3.1 |
| #7 | Y | Y | Y | Y | N | Y | 5.9 | 3.8 |
| #8 | Y | N | N | Y | N | N | 8.2 | 1.4 |
| #9 | Y | N | Y | Y | N | Y | 6.3 | 1.2 |
| #10 | Y | N | Y | Y | N | N | 11.2 | -3.0 |
| #11 | N | Y | N | Y | N | N | 8.0 | 0.1 |
| #12 | Y | N | Y | Y | N | Y | 7.9 | -2.0 |
| #13 | Y | Y | Y | Y | N | N | 9.9 | -3.3 |
| #14 | Y | Y | Y | Y | N | N | 9.6 | -3.2 |
| #15 | Y | Y | Y | Y | Y | N | 6.2 | 4.4 |
| #16 | Y | Y | N | Y | N | N | 6.8 | 5.7 |
| #17 | Y | N | Y | Y | N | Y | 7.6 | -3.1 |
| #18 | Y | Y | Y | Y | N | Y | 9.1 | -5.5 |
| #19 | Y | N | Y | Y | N | Y | 5.3 | 6.3 |
| #20 | Y | Y | Y | Y | Y | Y | 9.0 | 7.3 |
| #21 | Y | N | Y | Y | N | Y | 6.6 | 0.2 |
| #22 | Y | N | Y | Y | N | Y | 7.9 | -4.3 |
| #23 | Y | N | N | Y | N | N | 10.7 | 2.2 |
| #24 | Y | Y | Y | Y | N | Y | 11.2 | -2.0 |

Table 2. The number of anterior and posterior teeth of all subjects.

| | Crpt (n = 24) | | non-Crpt (n = 24) | |
|---|---|---|---|---|
| | mean | S.D. | mean | S.D. |
| maxillary anterior teeth | 6.0 | 0.0 | 5.9 | 0.3 |
| mandibular anterior teeth | 5.9 | 0.4 | 5.9 | 0.3 |
| maxillary posterior teeth | 7.9 | 0.4 | 7.9 | 0.4 |
| mandibular posterior teeth | 7.8 | 0.5 | 7.7 | 0.8 |

Table 3. Measurement errors for cephalometric angular and linear measurements.

| Variables | Measurement error | Coefficient of reliability |
|---|---|---|
| ANB (°) | 0.49 | 1.000 |
| SNA (°) | 0.65 | 0.994 |
| SNB (°) | 0.44 | 0.988 |
| SNP (°) | 0.40 | 0.987 |
| Facial angle (°) | 0.31 | 0.959 |
| Mandibular pl. to SN (°) | 0.55 | 1.000 |
| Mandibular pl. to FH (°) | 0.52 | 0.988 |
| Gonial angle (°) | 0.90 | 1.000 |
| GZN (°) | 1.10 | 0.999 |
| Ramus angle (°) | 1.09 | 1.000 |
| NSM (°) | 0.41 | 0.996 |
| Y-axis (°) | 0.44 | 0.952 |
| U1 to SN (°) | 0.53 | 1.000 |
| U1 to FH (°) | 0.64 | 1.000 |
| L1 to Mandibular pl. (°) | 0.69 | 0.990 |
| N-Me (mm) | 0.32 | 1.000 |
| ANS-Me (mm) | 0.34 | 0.993 |
| ANS-U1 (mm) | 0.30 | 1.000 |
| L1-Me (mm) | 0.16 | 1.000 |
| N-Ba (mm) | 0.72 | 1.000 |
| McNamara line to A (mm) | 0.61 | 1.000 |
| McNamara line to Pog (mm) | 0.82 | 1.000 |
| Cd-Gn (mm) | 0.75 | 1.000 |
| Cd-Go (mm) | 0.58 | 0.999 |
| Go-Pog´ (mm) | 0.57 | 0.990 |
| Wits appraisal (mm) | 0.67 | 1.000 |
| Overjet (mm) | 0.26 | 1.000 |
| Overbite (mm) | 0.15 | 1.000 |

Table 4. Pretreatment measurements of condylar ratios. **$P < 0.01$. CH: condylar height, RH: ramus height.

| | Crpt (n = 24) | | | | non-Crpt (n = 24) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Condylar ratios | mean | max | min | S.D. | mean | max | min | S.D. | *P* value |
| CH/RH (%) | 50.5 | 70.8 | 35.5 | 8.5 | 59.2 | 83.7 | 40.0 | 11.5 | 0.005** |
| CH/(CH+RH) (%) | 33.4 | 41.5 | 26.2 | 3.7 | 36.9 | 45.6 | 28.6 | 4.4 | 0.005** |

Table 5. Pretreatment angular measurements of cephalometric variables. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

| | Crpt (n = 24) | | | | non-Crpt (n = 24) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables (°) | mean | max | min | S.D. | mean | max | min | S.D. | *P* value |
| ANB | 8.0 | 12.8 | 5.9 | 1.9 | 7.6 | 10.3 | 5.2 | 1.7 | 0.480 |
| SNA | 79.3 | 85.8 | 72.5 | 3.1 | 81.5 | 88.0 | 76.4 | 3.5 | 0.023* |
| SNB | 71.3 | 77.4 | 64.6 | 3.4 | 73.9 | 79.9 | 70.2 | 2.8 | 0.005** |
| SNP | 70.3 | 76.9 | 62.5 | 3.7 | 73.4 | 79.0 | 69.0 | 3.0 | 0.002** |
| Facial angle | 78.8 | 83.2 | 73.3 | 2.8 | 82.1 | 86.4 | 77.8 | 2.4 | <0.001*** |
| Mandibular pl. to SN | 48.1 | 60.8 | 36.0 | 6.7 | 41.4 | 54.6 | 29.5 | 6.7 | 0.001** |
| Mandibular pl. to FH | 39.6 | 51.2 | 30.8 | 6.2 | 32.7 | 43.5 | 21.9 | 6.3 | <0.001*** |
| Gonial angle | 124.2 | 132.6 | 112.1 | 5.7 | 122.4 | 138.6 | 109.0 | 7.2 | 0.342 |
| GZN | 104.0 | 111.0 | 95.3 | 4.2 | 99.1 | 106.3 | 91.4 | 4.6 | <0.001*** |
| Ramus angle | -5.4 | 2.2 | -11.5 | 3.7 | -0.4 | 7.0 | -8.1 | 4.1 | <0.001*** |
| NSM | 79.7 | 88.3 | 73.1 | 4.0 | 76.3 | 83.5 | 70.6 | 3.5 | 0.003** |
| Y-axis | 71.2 | 78.5 | 65.6 | 3.4 | 67.7 | 72.2 | 62.3 | 3.1 | 0.001** |
| U1 to SN | 102.1 | 118.1 | 85.3 | 9.2 | 108.9 | 126.0 | 96.9 | 8.1 | 0.010* |
| U1 to FH | 110.7 | 122.8 | 94.3 | 8.5 | 117.6 | 134.4 | 104.2 | 7.7 | 0.005** |
| L1 to Mandibular pl. | 96.7 | 106.8 | 83.8 | 7.9 | 97.8 | 111.6 | 75.3 | 8.3 | 0.634 |

Table 6. Pretreatment linear measurements of cephalometric variables. $^{*}P<0.05$, $^{**}P<0.01$, $^{***}P<0.001$.

| | Crpt (n = 24) | | | | non-Crpt (n = 24) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables (mm) | mean | max | min | S.D. | mean | max | min | S.D. | *P* value |
| N-Me | 128.3 | 142.3 | 120.2 | 5.7 | 127.9 | 137.8 | 120.2 | 5.3 | 0.781 |
| ANS-Me | 70.2 | 78.6 | 64.9 | 3.7 | 71.2 | 80.9 | 62.0 | 5.0 | 0.462 |
| ANS-U1 | 33.2 | 36.8 | 28.1 | 2.2 | 31.6 | 37.7 | 24.7 | 2.7 | 0.030* |
| L1-Me | 39.1 | 44.9 | 34.7 | 2.8 | 42.2 | 49.8 | 38.2 | 3.0 | 0.001** |
| N-Ba | 106.4 | 116.9 | 101.1 | 3.6 | 107.4 | 113.9 | 96.2 | 4.4 | 0.375 |
| McNamara line to Pt A | -2.5 | 0.9 | -7.6 | 2.4 | 0.3 | 6.6 | -5.8 | 3.1 | 0.002** |
| McNamara line to Pog | -25.0 | -15.2 | -37.6 | 6.6 | -17.5 | -7.5 | -26.1 | 5.3 | <0.001*** |
| Cd-Gn | 110.3 | 120.0 | 96.0 | 6.0 | 115.7 | 122.9 | 109.9 | 3.8 | 0.001** |
| Cd-Go | 50.5 | 58.8 | 40.5 | 5.0 | 57.1 | 63.0 | 47.8 | 4.4 | <0.001*** |
| Go-Pog´ | 74.6 | 82.2 | 64.9 | 4.2 | 76.0 | 80.9 | 68.6 | 3.1 | 0.190 |
| Wits appraisal | 4.6 | 15.1 | -3.5 | 3.4 | 5.5 | 11.5 | -1.8 | 3.5 | 0.340 |
| Overjet | 8.2 | 11.3 | 4.6 | 2.1 | 10.1 | 16.7 | 5.6 | 3.1 | 0.015* |
| Overbite | -0.1 | 7.3 | -5.5 | 3.6 | 0.7 | 6.4 | -5.6 | 3.4 | 0.414 |

Table 7. Multiple linear regression analysis of the influence upon Overjet of Crpt group.

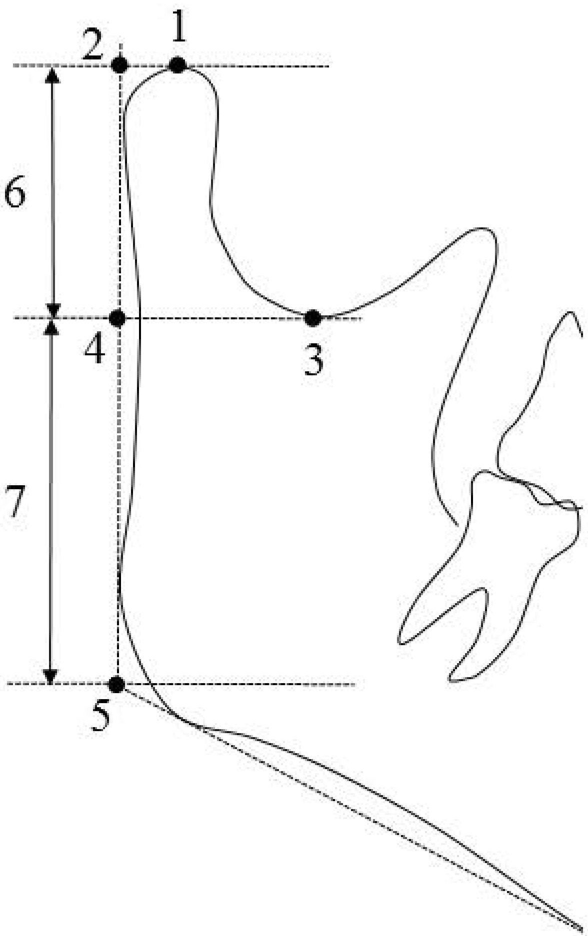
| | Coefficient | | | Correlations |
|---|---|---|---|---|
| Model | B | t | $P$ | Partial |
| Constant | -0.742 | -0.149 | 0.883 | |
| U1 to FH (°) | 0.156 | 4.351 | $<$0.001 | 0.629 |
| Cd-Go (mm) | -0.164 | -2.728 | 0.013 | -0.389 |

$R = 0.744$, $R^2 = 0.554$, $P < 0.001$.

Table 8. Multiple linear regression analysis of the influence upon Overjet of non-Crpt group.

| | Coefficient | | | Correlations |
|---|---|---|---|---|
| Model | B | t | *P* | Partial |
| Constant | 2.454 | 0.268 | 0.791 | |
| Wits appraisal (mm) | 0.372 | 2.672 | 0.015 | 0.636 |
| U1 to FH (°) | 0.146 | 2.312 | 0.032 | 0.622 |
| L1 to Mandibular pl. (°) | -0.118 | -2.306 | 0.032 | -0.413 |

$R = 0.792$, $R^2 = 0.627$, $P < 0.001$.



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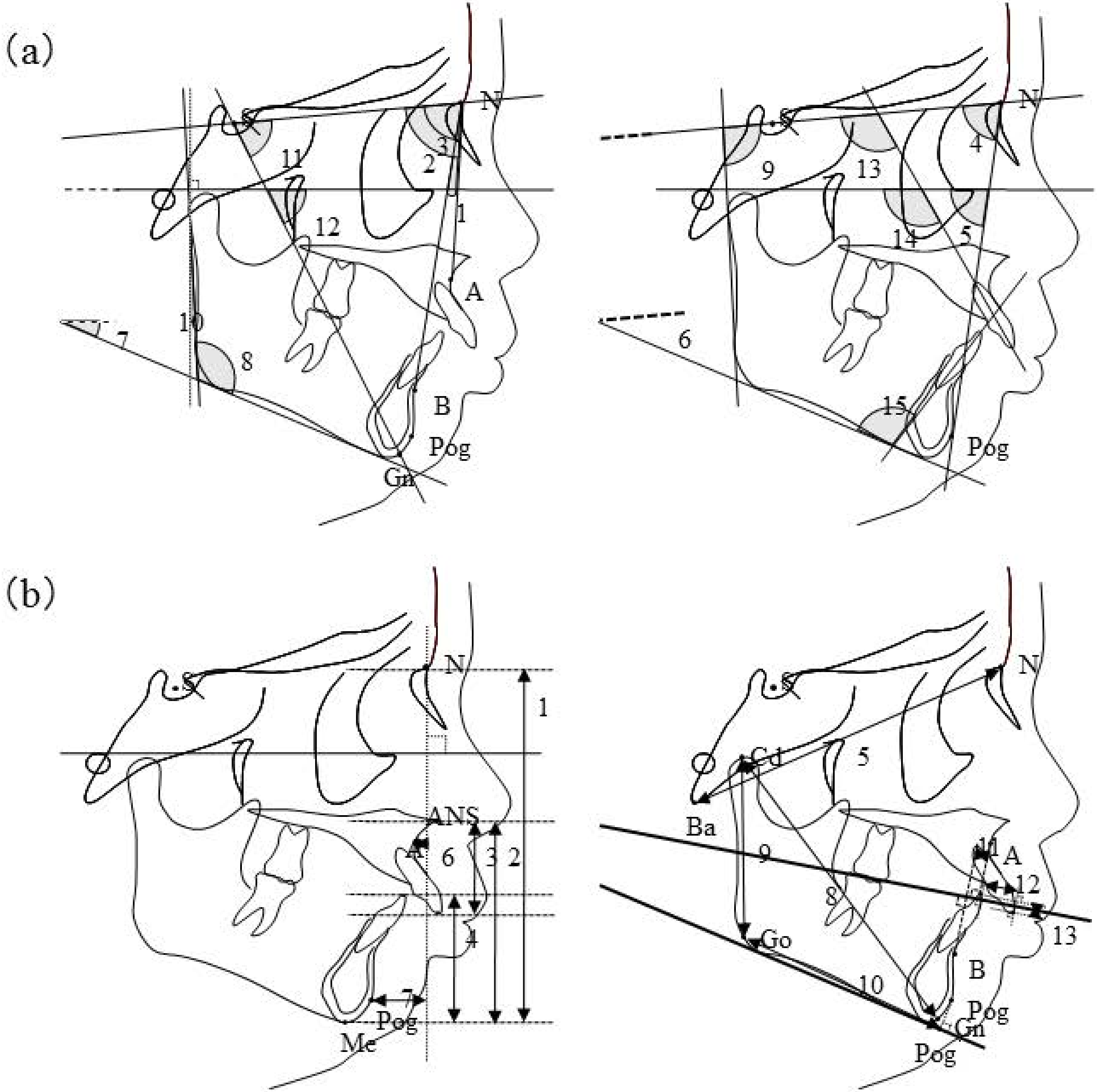

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